

WHAT IS CLAIMED IS:

1. A method of controlling an element within a patient's body which is responsive to a magnetic field, the method comprising applying at least two different...
5 magnetic fields to the element within the body to control the element, the magnetic fields having different angular relationships between the field direction and the gradient.
- 10 2. The method according to claim 1 wherein in one of the magnetic fields applied to the element, the gradient is substantially parallel to the field direction and wherein in another of the magnetic fields applied to the element the gradient is substantially perpendicular
15 to the field direction.
3. The method according to claim 2 wherein one of the fields applied to the element is an end field of a permanent magnet and one of the fields applied to the
20 element is a side field of a permanent magnet.
4. The method according to claim 3 wherein the permanent magnet is a multipole permanent magnet.
- 25 5. The method according to claim 4 wherein the multipole permanent magnet is a quadrupole permanent magnet.
6. The method according to claim 1 wherein the
30 magnet fields are applied with at least one permanent magnet.

7. The method according to claim 1 wherein the
magnetic fields are applied with at least one permanent
35 magnet.

8. The method according to claim 7 wherein the at
least two fields are applied to the element by changing
at least one of the position and orientation of the
40 magnet with respect to the patient.

9. The method according to claim 1 wherein the
magnetic fields are applied with at least one
electromagnetic coil.
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10. The method according to claim 9 wherein the at
least two fields are applied to the element by changing
at least one of the position and orientation of the
magnet with respect to the patient.
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11. The method according to claim 10 wherein the
magnetic fields are applied with at least one
superconducting electromagnetic coil.

12. The method according to claim 11 wherein the at
least two fields are applied to the element by changing
at least one of the position and orientation of the
magnet with respect to the patient.
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13. The method according to claim 11 where the
superconductor coil has a mechanical refrigerator
associated with it for maintaining the superconducting
state of the superconducting magnet coil.
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14. An improved method of controlling an element
within a patient's body which is responsive to a magnetic
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field through the controlled application of magnetic fields, the improvement comprising successively applying at least two different magnetic fields in which the angle
70 between the magnetic field direction and the gradient are different.

15. A method of controlling an element within the human body which is responsive to an applied magnetic
75 field, the method comprising applying a series of magnetic fields including fields in which the magnetic gradient is negligible for orienting the element along the field direction and fields in which the magnetic gradient is non-negligible and oblique to the magnetic
80 field direction for pulling the element in a direction different from the orientation of the element.

16. A method of controlling an element with the human body which is responsive to an applied magnetic
85 field, the method comprising applying a series of magnetic fields to control the element including fields in which the direction and strength of the magnetic gradient is negligible for orienting the element along the field direction and fields in which the magnetic
90 gradient is non-negligible and oblique to the magnetic field direction for pulling the element in a direction different from the orientation of the element.

17. A device for magnetically assisted surgery of a
95 patient comprising:

a magnet support structure;

a magnet having at least four poles, the magnet
-- attached to the magnet support structure so that the magnet provides a near-field magnetic field in an
100 operating region within a patient, the magnet being

moveable to alter a direction of magnetic field lines in the operating region within the patient.

18. The device of claim 17 wherein the magnet is a quadrupole magnet.

19. The device of claim 18 wherein the magnet is a permanent magnet.

20. The device of claim 19 wherein the magnet is generally cylindrical and has a radius and an axis perpendicular to its radius.

21. The device of claim 20 wherein the magnet comprises a pair of essentially semicircular segments joined so that the segments attract each other and provide, in a region proximate the magnet disk, a
5 magnetic field essentially parallel to the magnet disk along the axis of the magnet.

22. The device of claim 20 wherein the magnet is mounted rotatably on its axis so that a direction of magnetic field lines in the operating region of the patient may be varied.

23. The device of claim 22 and wherein the magnet is mounted translatable in at least one radial direction.

24. The device of claim 23 wherein the magnet is mounted so that it is translatable in a plurality of radial directions.

25. The device of claim 24 and further comprising a medical imaging system configured to provide a medical image of the operating region of the patient.

26. The device of claim 25 wherein the medical imaging system comprises an x-ray source and an x-ray imaging plate on opposite sides of the operating region of the patient, and further wherein the x-ray source and
5 x-ray imaging plate are positioned in a region entirely on one side of a face of the magnet.

27. The device of claim 18 wherein the magnet is a NdFeB maximum energy product.

28. The device of claim 27 wherein the magnet has a 44 MgOe composition.

29. The device of claim 28 wherein the magnet is disk-shaped and has a radius of about 12.39 inches and a thickness of 6.20 inches.

30. The device of claim 29 wherein the magnet provides a field of at least about 0.15 Tesla at 6 inches from its face.

31. The device of claim 17 wherein the magnet comprises at least one electromagnetic coil.

32. The device of claim 31 wherein the magnet comprises a continuously wound coil with a cross-over to
provide a quadrupole or higher-order magnetic field.

33. The device of claim 31 wherein the magnet comprises at least a pair of separately wound electromagnetic coils.

34. The device of claim 33 wherein the coils are each shaped in the form of a pie section and assembled into a circular configuration.

35. The device of claim 34 wherein the pair of separately wound electromagnetic coils are D-shaped, with a flat portion of each of the D-shaped coils adjacent one another.

36. The device of claim 22 wherein the at least one coil is superconducting.

37. The device according to claim 36 where the superconductor coil has a mechanical refrigerator associated with it for maintaining the superconducting state of the superconducting magnet coil.

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38. A device for magnetically assisting surgical operations, the device comprising:

a magnetic delivery vehicle configured to be introduced into a patient;

10 a magnet support base; and

a magnet assembly adjustably supported on the support base and positionable thereon to provide a magnetic field of specified direction and having an transverse gradient at a location in which the magnetic
15 delivery vehicle is introduced into a patient supported by the patient support structure.

39. The device of claim 38 wherein the magnet assembly comprises a computer-controlled robotic arm having a magnetic effector.

40. The device of claim 37 and further comprising a medical imaging device configured to provide a relative location and orientation of the magnetic delivery vehicle, the magnet assembly, and the operating region of
5 the patient.